FY08 Bi-Annual Report

WIRELESS COOPERATIVE NETWORKS: SELF-CONFIGURATION AND OPTIMIZATION

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Distributed multi-input multi-output (MIMO) system is a promising architecture to provide reliable communications over spatially separated relaying nodes. In this paper, we will investigate the optimum resource allocation techniques in distributed MIMO systems, employing differential (de)modulation and various relaying protocols. Instead of limiting to energy optimization, we solve this problem via a two-dimensional energy and location optimization. Benefits of our resource optimization approaches are illustrated through extensive analysis and simulations. Comparisons between different optimization techniques and systems with different protocols are also included.

15. SUBJECT TERMS

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A Abstract

Distributed multi-input multi-output (MIMO) system is a promising architecture to provide reliable communications over spatially separated relaying nodes. In this paper, we will investigate the optimum resource allocation techniques in distributed MIMO systems, employing differential (de)modulation and various relaying protocols. Instead of limiting to energy optimization, we solve this problem via a two-dimensional energy and location optimization. Benefits of our resource optimization approaches are illustrated through extensive analysis and simulations. Comparisons between different optimization techniques and systems with different protocols are also included.

B Technical Results

Based on our previous work, we provide an upper bound of the symbol error rate (SER) for decode-and-forward (DF) systems and an approximated SER for amplify-and-forward (AF) systems. We proved that the system SER is a convex function in both the transmit energy and the relay location, and then carried out the two-dimensional energy and location optimization through numerical search. As we know, system energy is a limited resource, especially for mobile terminals, and the coverage area is a critical factor to judge the system performance. Therefore, we evaluate the benefits of our optimization techniques in terms of the system energy saving and the coverage distance extension.

The simulations reveal several interesting results. For both DF and AF protocols, the optimized systems always outperform the unoptimized systems with either less energy consumption or longer transmission range. It is also noticed that the benefits of both energy and location optimizations vary a lot for different protocols, and with different system configurations. Uniform energy allocation and midpoint relay location are normally chosen as an initial system setup. For such a configuration with DF protocol, location optimization is more critical than energy optimization, and the unoptimized system receives prominent benefits from both optimizations, and tremendous system resources savings. For AF protocol, however, location and energy optimizations are equally important for the unoptimized system. It turns out that the uniform energy allocation and the midpoint relay location result in fairly good system performance, since it is reasonably close to the global optimum.

For other initial system setups, the optimization benefits are also distinct in AF and DF systems. In DF systems, more optimization benefits can be achieved when the relays are either close to the destination or have more transmit energy allocated to the relay(s). On the contrary, in AF systems, remarkable optimization benefits will be achieved when the relays are far from the midpoint, or when the relays are only able to transmit at low energy levels.

To enable the implementation of such an optimum strategy in wireless sensor networks, the sensor nodes need to know their precise (absolute or relative) locations. In the past, the Global Positioning System (GPS) has been the major method for wireless localization and navigation. However, its application is constrained since the GPS signal is not available in indoor, metropolitan and heavy-foliage scenarios which, more often than not, are where the sensor networks are deployed. Therefore, we need to exploit alternative terrestrial wireless signals for positioning and navigation. In our work, we consider both the ultra-wideband (UWB) signals that are intentionally set up, and the wireless local area network (WLAN) IEEE 802.11a/g signals that are widely available and are known as the "signal-of-opportunity." For both signals, we investigate the time-difference-of-arrival (TDoA) based ranging and localization.

The Cramer-Rao Bound (CRB) analysis reveals that broadband signals can provide high accuracy timing and localization. In order to exploit this capability, we propose a high-precision time-of-arrival (ToA) estimator for broadband wireless systems. By *focusing on the first arrival* (FoFa), our approach has the advantage of high resolution and low complexity, in comparison with existing alternatives. In addition, no analog or oversampled waveform is needed. Our algorithm is built on, and requires minimum modification of, the frequency domain equalizers that are widely adopted for broadband wireless systems. Simulations show that our proposed FoFa estimator outperforms the well-known space alternating generalized expectation maximization estimator in terms of the ToA estimation accuracy for both the line-of-sight and non-line-of-sight channels.

C Publications

[1] W. Cho, R. Cao and L. Yang, "Optimum Resource Allocation for Amplify-and-Forward Relay Networks with Differential Modulation," *IEEE Transactions on Signal Processing*, 2008 (to appear).

[2] F. Qu, D. Duan, L. Yang and A. Swami, "Signaling with Imperfect Channel State Information: A Battery Power Efficiency Comparison," *IEEE Transactions on Signal Processing*, 2008 (to appear).

[3] W. Cho and L. Yang, "Optimum resource allocation for relay networks with differential modulation," *IEEE Transactions on Communications*, vol. 56, no. 4, pp. 531–534, April 2008.

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